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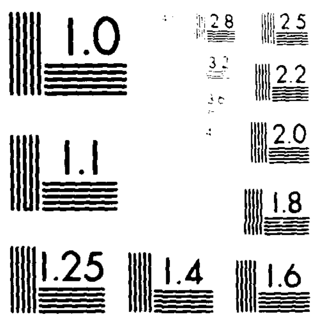

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TECHNICAL REPORT 113

IMPROVED PROCEDURES TRAINING THROUGH USE OF AIDS DEVELOPED FROM LEARNING GUIDELINES

FEBRUARY 1982

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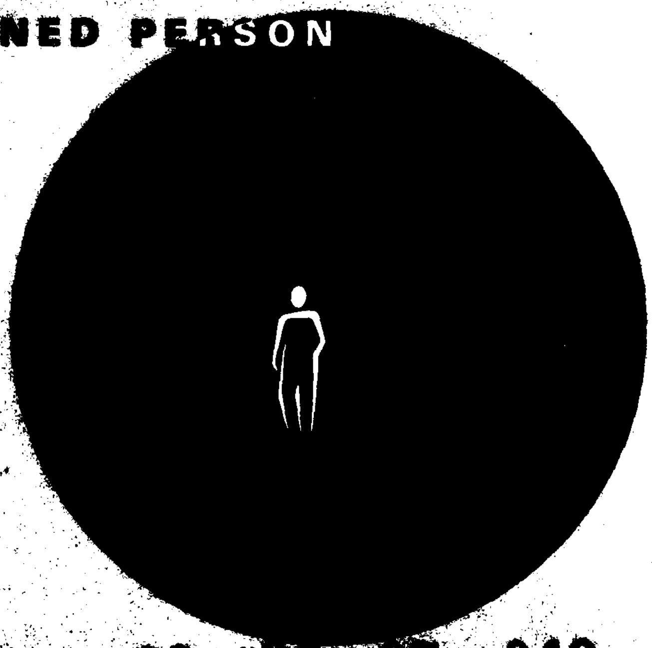

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TRAINING ANALYSIS AND EVALUATION GROUP
ORLANDO FLORIDA 32813

Technical Report No. 113

IMPROVED PROCEDURES TRAINING THROUGH USE OF AIDS DEVELOPED FROM LEARNING GUIDELINES

Paul G. Scott
William C. McDaniel
Richard Braby

Training Analysis and Evaluation Group

February 1982

Sponsored by

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This report describes the development of a procedural training aid for the SH-3 Aircraft Normal Start Checklist. The results of a comparative evaluation of the training aid with the traditional squadron materials used for procedures training are provided.

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TABLE OF CONTENTS

Section		Page
I	INTRODUCTION	3
	Purpose	3
II	SH-3 PROCEDURE TRAINING AID DEVELOPMENT	5
	Procedural Training Materials	5
III	METHOD	17
	Subjects	17
	Materials	17
	Procedure	17
IV	RESULTS	19
	First Trial Performance	19
	Sequential Trial Performance	19
V	CONCLUSIONS AND RECOMMENDATIONS	23
	Conclusions	23
	Recommendations	23
	Post Note	24
REFERENCES		25

LIST OF ILLUSTRATIONS

Figure		Page
1	SH-3D/H NATOPS Pilots' Checklist	7
2	Workbook Lesson AF1-7-1 Challenges 29 and 30	8
3	Diagram A from Workbook Lesson AF1-7-1	9
4	Diagram E from Workbook Lesson AF1-7-1	10
5	Item 28, No. 1 Overspeed System, from Procedure Training Aid	11
6	Paper Mock-up and Procedure Training Aid Being Used in Student Carrel	15
7	Results of Engine Start Field Test Showing Cumulative Subject Proficiency Attainment for Two Types of Training Materials	20
8	Average Total Trials and Trials to Proficiency for Control and Experimental Groups	22

SECTION I

INTRODUCTION

A major portion of SH-3 replacement pilot training requires the student aviator to learn and master many complex procedures. Improving the materials and methods used to teach these complex procedures would substantially increase both the training effectiveness and efficiency of the total training program.

The manner in which procedures are organized and presented affects both learning time and subsequent job performance. Aagard and Braby (1976) suggest several learning guidelines are useful in developing procedural learning aids. Polino and Braby (1980) demonstrated the superiority of learning aids that incorporated these learning guidelines. Groups using the learning aid performed a simple procedure with fewer errors than groups using job performance aids or traditional narrative handbook materials. Results further indicate that although both high and low aptitude students benefited from the training aid, lower aptitude students performed considerably better. This finding suggests the learning aid may reduce variability in student performance resulting from individual differences.

A training analysis conducted to evaluate the effectiveness of a new state-of-the-art flight simulator (Browning, McDaniel, and Scott, 1981) revealed that first tour aviators experienced considerable difficulty in performing complex procedures. Examination of the then current student workbook and other academic materials suggested the students' problems in part stemmed from the manner in which procedures were organized and presented.

Based on previous research by Polino and Braby (1980) it was envisaged that the organization and format proposed by Aagard and Braby (1976) would provide a solution to student problems. Further, it was envisaged that development of procedural training aids would extend the Polino and Braby (1980) findings from simple procedures to long, complex procedural checklists.

PURPOSE

The purpose of this report is to describe the development of a procedural training aid for the SH-3 Aircraft Normal Start Checklist and to provide the results of a comparative evaluation of the training aid with the traditional squadron materials used for procedures training. In addition, the results of this comparative evaluation should serve to further validate the efficacy of producing training aids incorporating proven learning guidelines for enhancing student learning of procedural tasks.

SECTION II

SH-3 PROCEDURE TRAINING AID DEVELOPMENT

This section presents the background for the development of a Procedure Training Aid for teaching the Normal Start Checklist for the SH-3D/H helicopter. This effort was performed in conjunction with the Training Effectiveness Evaluation of Device 2F64C Operational Flight Trainer (OFT) currently underway at Helicopter Antisubmarine Squadron ONE (HS1), the East Coast SH-3 Fleet Replacement Squadron (FRS).

PROCEDURAL TRAINING MATERIALS

Prior to the start of the Training Effectiveness Evaluation at HS1, an instructional system development (ISD) effort had been performed at HS10, the West Coast SH-3 FRS. One of the outputs of this ISD effort was a student workbook to be used along with the NATOPS Flight Manual for the SH-3D/H for individual study to learn various procedures and checklists. The NATOPS flight manual contains information on all aircraft systems, performance data, and operating procedures required for safe and efficient operations. Neither the NATOPS Flight Manual nor the workbook lessons provided sufficient detail in the text or illustrations to facilitate learning the steps subsumed under each item of the 32-item Normal Start Checklist. Data collected from the control group, plus observations by TAEG personnel monitoring the control group training in the cockpit procedures trainer (Device 2C44), revealed that students encountered problems in mastering the approximately 200 individual steps in the 32-item Normal Start Checklist. The students' problems were due, in part, to the lack of a step-by-step NATOPS procedure for completing each item on the checklist and to variations in instruction. The SH-3D/H NATOPS Pilots Checklist for Normal Start is shown in figure 1. Figures 2, 3, and 4 are excerpts from lesson AF1-7-1 of the student workbook in which challenges 29 and 30 provide verbal and graphic information for item 28 on the pilots checklist.

Given the problems of (1) the requirement to learn complex checklists without sufficient detailed information organized in an appropriate manner for learning, (2) the varying instructor technique in teaching the checklist, and (3) students with varying abilities, the best solution appeared to be development of a Procedure Training Aid that satisfies the following learning guidelines (see Aagard and Braby, 1976).

1. divide procedural steps into small groups if students are of low ability, the procedures are complex, or the entire procedure is lengthy

2. demonstrate each step of the task in an observable model

3. direct the student to practice individual steps, then groups of steps, and, finally, the entire procedure

4. make early training easy by providing:

- immediate and frequent feedback on results
- guided and prompted responses

5. help the student transfer from a training aid to using a cockpit procedure trainer or the actual equipment by:
   - using photographs or detailed line drawings of the equipment so that the student recognizes and locates the equipment, controls, and displays
   - requiring the student to touch the proper place on the paper mock-up to practice the same kind of perceptual-motor tasks and chaining of steps required to operate the actual equipment.

By following these guidelines, the Procedure Training Aid for the Normal Start Checklist and a paper mock-up of the SH-3 cockpit were developed.

The Procedure Training Aid was developed using photographs and step-by-step instructions for discrete behaviors used in completing the Normal Start Procedures. The entire SH-3D/H Normal Start Checklist Procedure Training Aid has been published separately by Braby and Scott (1982). The section of the Procedure Training Aid that describes that part of the procedure for item 28, No. 1 Overspeed System Check, is illustrated in figure 5. The figure shows the procedure with the key words underlined and then with the key words left out for memory check exercises. Comparison of this figure with the previous instructions in the *NATOPS manual* and the *student workbook* (lesson AF1-7-1), Normal Start Engine Checklist, shown in figure 2, clearly shows the differences in detail provided the student.

The paper mock-up is a three section line drawing, each section measuring 17 inches x 22 inches. The paper mock-up was designed to fit in a training carrel. Careful attention was given to ensuring that both the detail was readable and that the switches and settings were in the position a student would expect during the normal start procedure. Figure 6 shows a typical use of the training aid and paper mock-up in a student carrel.

To test the effectiveness of the Procedure Training Aid, a comparative evaluation was conducted. The method used to perform this evaluation is presented in the next section of this report.

NAVAIR 01-230HLH-1C

SH-3D/H NATOPS PILOTS' CHECKLIST

NORMAL PROCEDURES

This checklist superseded NAVAIR 01-230HLH-1C dated 1 March 1977
and NAVAIR 01-230HLE-1B dated 1 December 1975

NORMAL START

1. Circuit Breakers and Switches. . . . . CHECK
2. Fuel Dump Switches . . . . OFF
3. Brakes and Tailwheel . . . . .LOCKED
4. Battery Switch . . . . .ON
5. External Power . . . . CONNECTED
6. Battery Switch . . . . OFF
7. Landing Gear . . . . CHECK
8. Drop Tank Switch Panel(SH-3H). . . . . CHECK
9. Start Mode Switch. . . . . AS REQUIRED
10. Blade Panel(Radios SH-3D),Hoist, Trim. . . . . CHECK
11. Torquemotor Switches . . . . OFF
12. Anti-ice . . . . CHECK AS REQUIRED
13. Ignition Switches. . . . . .NORMAL
14. Accessory Drive Switch . . . . FORWARD, LIGHT ON
15. Manual Throttles, Speed Selectors. . . . . .FREE AND OFF
16. Emergency Start and Override Switches. . . . . OFF
17. Rotor Brake. . . . . .CHECKED(320 PSI MINIMUM)
18. Fire Warning, Caution, Advisory Panels . . . . CHECK
19. PMS Disable Switch(SH-3H). . . . . .PULL
20. Fuel Panel/Quantity. . . . . CHECK
21. Battery Switch . . . . .ON
22. Lights . . . . AS REQUIRED
23. No. 1 Engine . . . . START
24. All Gages. . . . . CHECK
25. Boost Pumps. . . . . OFF
26. Speed Selector . . . . 104% Nf
27. Generators . . . . .ON
28. No. 1 Overspeed System . . . . CHECK
29. External Power . . . . .DISCONNECTED
30. Compass System, Console Switches . . . . AS REQUIRED
31. RAD ALT, BAR ALT, RAWS .SET AND TEST
32. Servo Sensor . . . . CHECK

Extracted from NAVAIR 01-230HLH-1C

Figure 1. SH-3D/H NATOPS Pilots' Checklist

NORMAL START ENGINE CHECKLIST

CHALLENGE	REPLY	NOTE
25. ALL GAGES	Checked	a. N_g - - 56 $\pm$ 3%. b. T_5 - - Approximately 500°C c. Engine oil temp (A-19, C-15) -no change will be initially detectable. Normal range is 35 - 121°C. d. Engine oil pressure - at or above 10 PSI. e. Trans oil pressure (A-19, C-16) -above zero. f. Trans oil temp (A-19, C-17) -no change will be initially detectable. Normal range is 40 - 120°C. g. Hydraulic pressures (A-19, C-18) -normal. (Primary pressure zero if blades folded). h. No. 1 N_f (A-19,C-19) - approximately 45 - 55%. i. Torque (A-19, C-20) - zero.
26. BOOST PUMPS	OFF	Booster pumps should be off to check for engine flame out due to possible air leak in a fuel line. If airframe fuel filters have been changed just before the flight, the boost pumps should be left on for about one minute after starting engine to purge air from fuel lines and to preclude engine flame-out.
27. SPEED SELECTOR	104% N_f	This brings the accessory section of the Main gear box up to normal speed.
28. GENERATORS	ON (A-18, B-17)	Connects AC generators to the electrical system.
29. NO. 1 OVERSPEED TEST SWITCH	ON (A-21, E-3)	N_f should droop to between 95 and 100%. If the engines are RFI (Radio Frequency Interference) shielded, the N_f will droop to between 88 and 99%.
30. NO. 1 OVERSPEED OVERRIDE SWITCH	ON - OFF	N_f should return to 104%. Release the the test switch and return the override switch to OFF.
31. EXTERNAL POWER	Disconnected	
32. COMPASS SYSTEM CONSOLE SWITCHES	As required	Slave and align the compass system (A-15) and energize desired equipment on the console (A-16).

Figure 2. Workbook Lesson AF1-7-1 Challenges 29 and 30

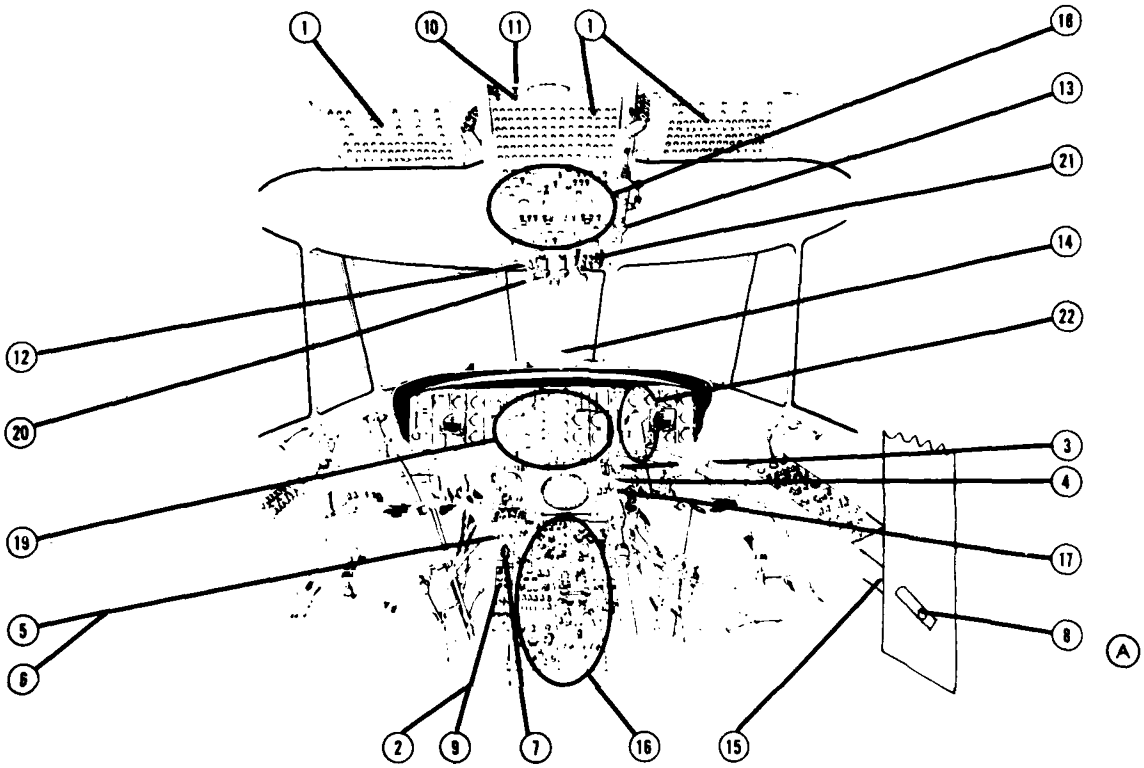


DIAGRAM A
COCKPIT AREA

ITEM LOCATION

1. Circuit Breakers
2. Fuel Dump Switches
3. Brakes
4. Tailwheel
5. Landing Gear Actuating Lever
6. Landing Gear Warning Light
7. Emerg Landing Gear Extension Handle
8. Emerg Landing Gear Release Lever
9. Drop Tank Switch Panel
10. Start Mode Switch
11. Channel Monitor Test Switch
12. Accessory Drive Switch
13. Rotor Brake
14. Wet Compass
15. Compass Control Panel
16. Console Area
17. Auxillary Servo Switch

LOCATION OF DIAGRAM

18. Overhead Switch Panel, Diagram B
19. Instrument Panel Diagram C
20. Throttle Quadrant, Diagram D
21. Emerg Start and Override Switches, Diagram E
22. Cyclic Stick Grip, Diagram F

Figure 3. Diagram A From Workbook Lesson AF1-7-1

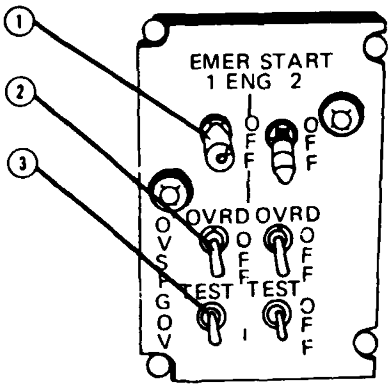


DIAGRAM E

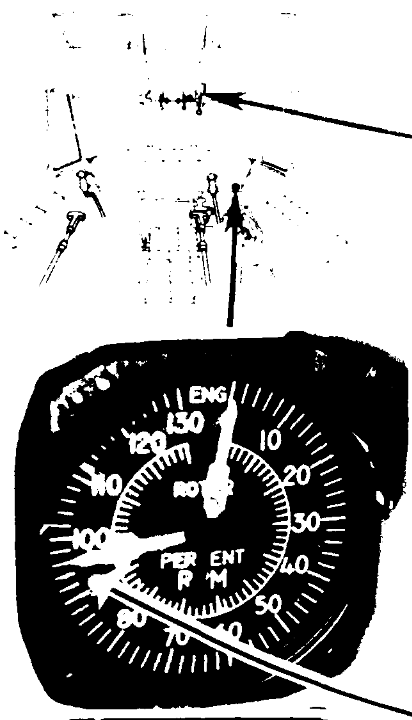
ENGINE EMERGENCY STARTING
AND OVERSPEED SWITCHES

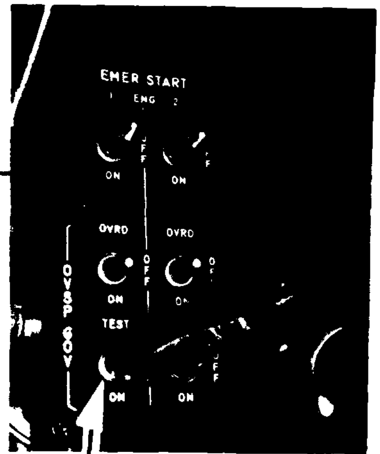
1. Emergency Start Switches
2. Overspeed Override Switches
3. Overspeed Test Switches

Figure 4. Diagram E From Workbook AF1-7-1

NORMAL START CHECKLIST ITEM NO. 28. No. 1 Overspeed System ...... CHECK

Purpose: To simulate an overspeed condition for checking the electrical overspeed system.

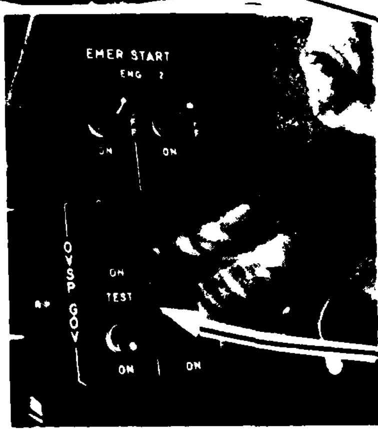




1. Action
   Pilot place OVSP GOV TEST switch to ON (FWD)
   Hold in this position

2. Result
   Nf will drop to between 95 and 100%

3. IF
   Engines are RFI (Radio Frequency Interference) shielded
   THEN
   Nf will drop to between 88 and 99%

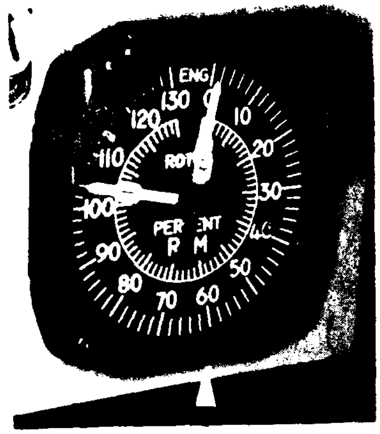


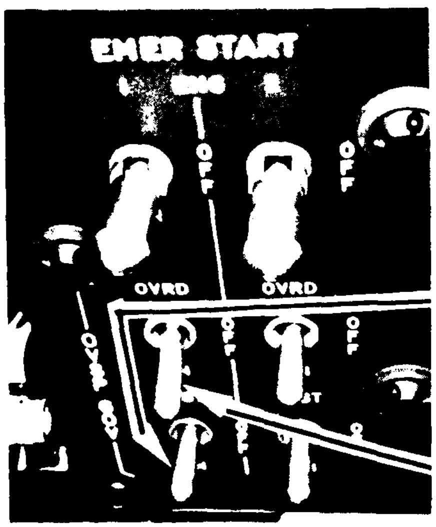
4. Action
   Pilot place OVSP GOV OVRD switch to ON (FWD)

Figure 5. Item 28, No. 1 Overspeed System, From Procedure Training Aid

NORMAL START CHECKLIST ITEM NO. 28. No. 1 Overspeed System ...... CHECK

EXERCISE ● FILL IN THE BLANKS ● WRITE ON SCRATCH PAPER – NOT THE BOOK ● REFER BACK TO CHECK YOUR ANSWERS





5. Result

Nf should return to 104

6. Action

Release OVSP GOV TEST switch (spring loaded to OFF)

7. Action

Pilot place OVSP GOV OVRD switch to OFF (AFT)

8. Voice Response

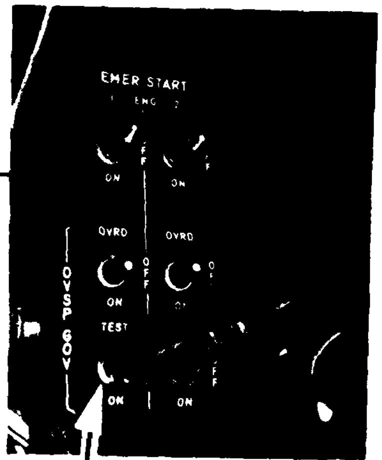
"CHECK"

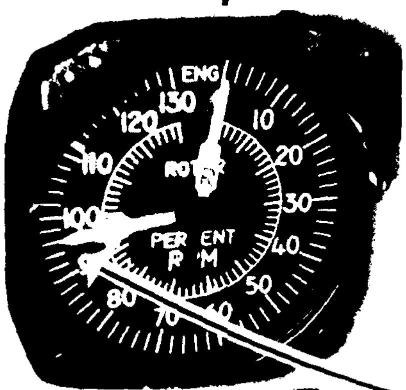
GO TO PAPER MOCK-UP ● STEP THROUGH ITEM ● TOUCH WHERE EACH ACTION AND RESPONSE TAKES PLACE

Figure 5. Item 28, No. 1 Overspeed System, From Procedure Training Aid (continued)

NORMAL START CHECKLIST ITEM NO. 28. No. 1 Overspeed System ...... CHECK

EXERCISE ● FILL IN THE BLANKS ● WRITE ON SCRATCH PAPER – NOT THE BOOK ● REFER BACK TO CHECK YOUR ANSWERS





1. Action

   Pilot place OVSP GOV TEST switch to ON ( )

   Hold in this position

2. Result

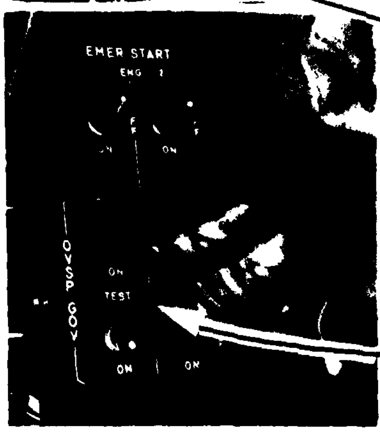
   Nf will drop to between _ and _

3. IF

   Engines are RFI (Radio Frequency Interference) shielded

   THEN

   Nf will drop to between _ and _



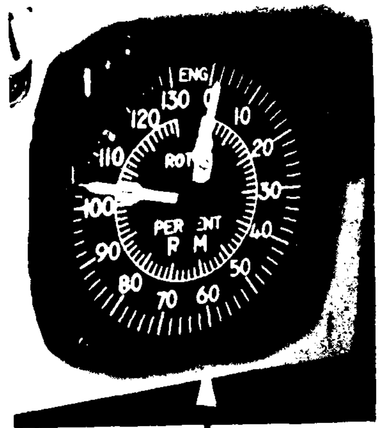
4. Action

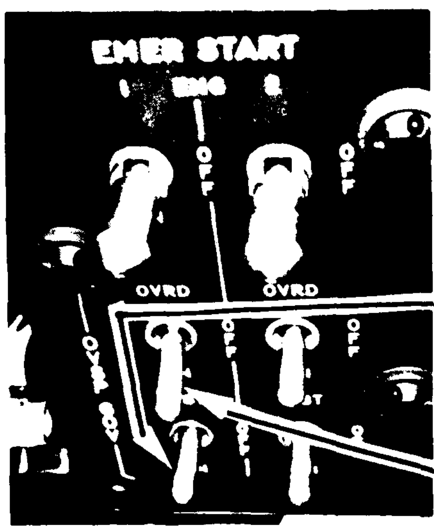
   Pilot place OVSP GOV OVRD switch to ON ( )

Figure 5. Item 28, No. 1 Overspeed System, From Procedure Training Aid (continued)

NORMAL START CHECKLIST ITEM NO. 28. No. 1 Overspeed System ...... CHECK

Purpose: To simulate an overspeed condition for checking the electrical overspeed system.





5. Result

Nf should return to ___

6. Action

___ OVSP GOV TEST switch (spring loaded to OFF)

7. Action

Pilot place OVSP GOV OVRD switch to ___ ___

8. Voice Response

___

GO TO PAPER MOCK-UP
- STEP THROUGH ITEM
- TOUCH WHERE EACH ACTION AND RESPONSE TAKES PLACE

Figure 5. Item 28, No. 1 Overspeed System, From Procedure Training Aid (continued)

Figure 6. Paper Mock-up and Procedure Trainer Being Used in Student Carrel

SECTION III

METHOD

SUBJECTS

Thirty-five newly designated Naval Aviators undergoing FRS training at HS1 Naval Air Station, Jacksonville, Florida, served as subjects in this evaluation. These aviators had no prior experience in the SH-3 aircraft. Sixteen of the subjects, designated the control group, received training using the existing instructional workbook materials developed for learning the Normal Start Procedures. Nineteen subjects, designated the experimental group, received the Procedure Training Aid developed by TAEG in lieu of the workbook materials.

MATERIALS

All control group subjects were provided with the NATOPS manual for the SH-3 aircraft and the workbook lesson normally used in academic training at HS1.

The experimental group was provided with the NATOPS manual and the Procedure Training Aid for the Normal Start Checklist developed by TAEG. A paper mock-up of the SH-3 cockpit and controls was also provided to be used in conjunction with the Procedure Training Aid.

Device 2C44, a cockpit procedures trainer (CPT), was used to assess the effectiveness of training from the written materials. The CPT provides controls and functional instrumentation similar to the SH-3 aircraft. This device effectively provides hands-on practice for performing procedural tasks.

PROCEDURE

Upon initial assignment to the FRS for pilot training, control group subjects were provided academic and written materials to learn the various procedures necessary to operate the SH-3 aircraft. After sufficient time for familiarization and learning of these procedures, subjects were scheduled for a training session in the CPT. The subject proceeded through the normal start procedure and upon completion of each trial was graded by the instructor. Based on procedures detailed in Browning, Ryan, and Scott (1978) and Browning, McDaniel, and Scott (1981), the trials were graded using a dichotomous scale, with trials performed to NATOPS standard graded a P and trials not performed to standard graded a 1. These graded trials were recorded in the sequence they were performed. The sequence of task trials were then evaluated to determine the point in the sequence of trials that reflected a consistent, reliable graded performance to NATOPS standards.

Procedures used for the experimental group were similar to those used with the control group. Experimental group subjects were given the Procedure Training Aid and paper mock-up and instructed to use these materials in accordance with the directions provided. Upon completion of

the Procedure Training Aid, the subject was scheduled for a session in the CPT to determine his performance and for additional training if necessary.

Because communications among students are high, it was important to ensure that the control group did not have access to these materials. This was done by not distributing the training aid until the control group had completed training.

SECTION IV

RESULTS

Two approaches were used to analyze trial data gathered from CPT training to determine the efficacy of the Procedure Training Aid. The first approach examined performance of students on their initial attempt to accomplish the engine start in the CPT (Device 2C44). Success on the first attempt would indicate the information in the training aid was complete, accurate and in a format conducive to transfer to the actual equipment. The second approach examined each student's sequence of graded trials to determine the point at which the normal start task was performed reliably and consistently to NATOPS standards. Differences found between the two groups using complete trial performance would indicate that learning was more permanent or longer lasting than would be inferred from just the data of the first trial. A reduction in the range of trials required to reach reliable and consistent performance would indicate improved learning as a function of the antecedent conditions. Fewer trials required by the experimental group would indicate superiority of the Procedure Training Aid for learning the normal start task prior to hands-on equipment practice.

FIRST TRIAL PERFORMANCE

The data indicate a significant difference in first trial performance in the CPT as a function of the design of the antecedent training. Twelve of the nineteen students trained with the Procedure Training Aid performed the engine start procedure correctly on the first attempt in the CPT. This compares with 2 students out of 16 who performed the procedure correctly the first time in the CPT after using the traditional materials. The performance of the group using the Procedure Training Aid was superior (chi square = 9.3, $p < .005$).

SEQUENTIAL TRIAL PERFORMANCE

The number of trials required to reach a level of consistent, reliable normal start procedure performance in accordance with NATOPS standards was determined from each student's sequence of trial data. Fisher's F test for homogeneity of variance (Cochran and Cox, 1957) revealed significant differences in variance between the two groups at the .01 level of significance ($F_{15,\ 18df} = 4.00$). This finding indicates the variability of trials required to achieve proficiency for the control group was considerably higher than for the experimental group. Figure 7 shows the cumulative percentage of subjects attaining proficiency on successive trials as a function of the antecedent training provided. The control group (without the training aid) required from one to ten trials to demonstrate proficiency while all of the experimental group (with the Procedure Training Aid) had attained proficiency by the fifth trial.

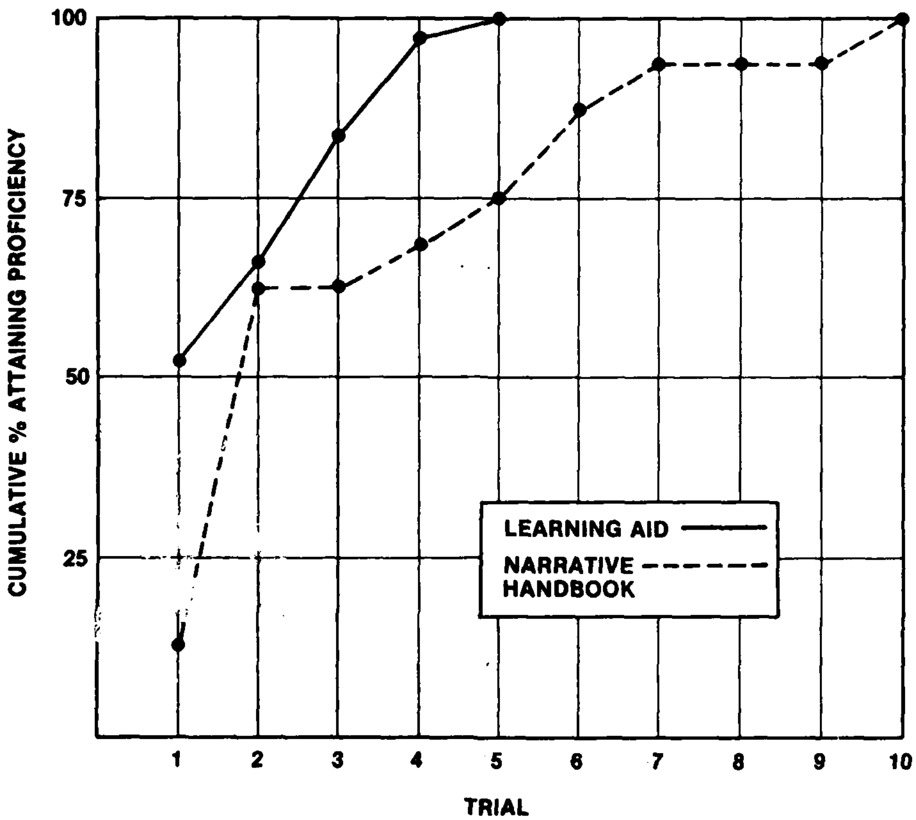


Figure 7. Results of Engine Start Field Test Showing Cumulative Subject Proficiency Attainment for Two Types of Training Materials

The average total practice trials for the control group was 9.6 with an average of 3.5 trials required to perform the task reliably and consistently. This compares with an average total of 4.3 practice trials for the experimental group and 2.0 trials to attain proficiency. The control group and experimental group subjects were judged proficient at the point in the sequence of trials where all subsequent trials were graded P. These results are shown in figure 8. A $\underline{t}$ test (one tailed) for independent groups was used to determine if the difference between groups to reach proficiency was reliable. A $\underline{t}$ test (assuming nonhomogeneity of variance based on Cochran and Cox (1957)) was used to test differences between groups for trials required to attain proficiency. The results indicated reliable differences at the .05 level of significance ($\underline{t}' = 1.760$).

Since earlier proficiency is attained with the Procedure Training Aid on the Normal Start task, it is logical to assume that more training time could be allocated to other tasks; e.g., normal checklist and emergency and malfunction procedures. Thus, it appears that the training aid provides significantly improved training in a specific procedural task and also contributes to more efficient training.

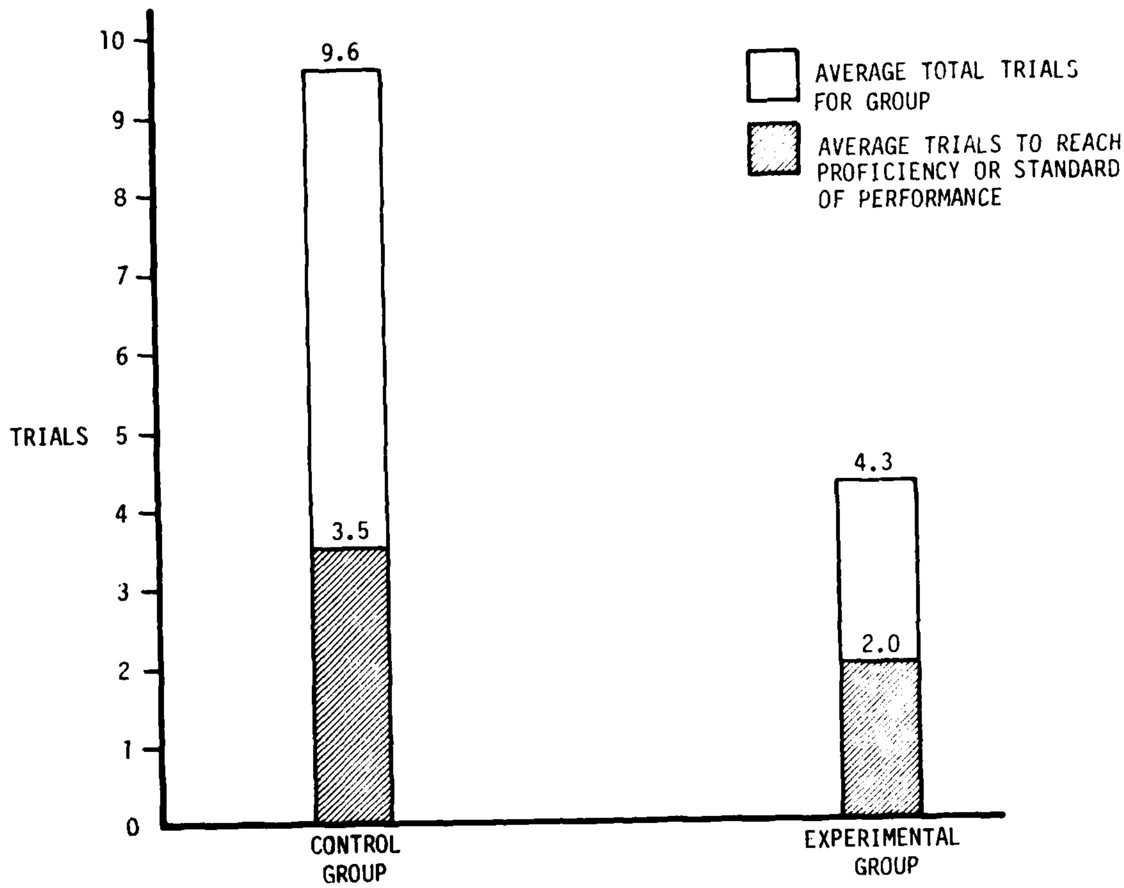


Figure 8. Average Total Trials and Trials to Proficiency for Control and Experimental Groups

SECTION V

CONCLUSIONS AND RECOMMENDATIONS

Conclusions and recommendations concerned with the results of using a procedural training aid at HS1 in place of the traditional training material are presented in this section. Also, a discussion is provided on further uses, development, and evaluations that should be considered.

CONCLUSIONS

- The Procedure Training Aid format provides complete and sufficient information needed by the student to accomplish the procedure.

- Using the Procedure Training Aid results in superior performance for all students as reflected by the fewer trials required to attain acceptable levels of proficiency. Possible reasons for this conclusion are:

  - The student is more oriented to the location of items in the cockpit due to the emphasis on visual information.

  - Requiring students to accomplish the steps in the Procedure Training Aid on the paper mock-up provided preliminary hand-eye coordination for performance in the CPT

  - The completeness and detail of the information substantially reduced student frustration in learning the procedure.

- Using the Procedure Training Aid required less hands-on training time for students in the CPT. This effectively provides additional training time for the student to practice other procedures.

- Variability in student performance was reduced.

- Students using the Procedure Training Aid appeared to experience less difficulty in follow-on procedural tasks. This may be attributed to:

  - Completeness of the information provided by the training aid was helpful in other procedures.

  - Confidence gained from performing this basic procedure correctly on the first trial provided reinforcement for performing other procedures.

RECOMMENDATIONS

- HS1 should institute the use of the Procedure Training Aid for the SH-3 Normal Start Procedure.

- Use the format for training aids for other procedures that must be performed from memory, or with a checklist, when one or more of the following conditions exist. The procedure:
  - .. is complex or difficult to learn
  - .. must be performed quickly - no time to "look it up"
  - .. must be learned early in the training program
  - .. must be performed in training on scarce or expensive equipment.

The Naval Technical Information Presentation Program and the Instructional Program Development Centers should use this format for training materials on appropriate procedures.

POST NOTE

The development and evaluation of the Normal Start Procedure Training Aid at HS1 resulted in requests from squadron personnel with responsibility for training enlisted replacement aircrewmen (RAC) for assistance in developing similar aids. They recognized that similar aids should alleviate problems RACs were encountering in mastering power-on and power-off procedures for Sound Navigation Ranging (SONAR) and Magnetic Anomaly Detection (MAD).

With assistance from the TAEG, a subject matter expert of the HS1 training department was instructed in how to construct a procedure training aid. In addition, a Procedure Training Aid for SH-3H AQS-13E SONAR Initial Control Setting was developed by HS1 and is currently in use. Also, a guide was developed and published for the field preparation of procedure training aids (Terrell, 1982). Subsequently, HS1 is developing three additional modules for training replacement aircrewmen. These training aids are designed to teach RACs SONAR and MAD preflight power-on checks. These modules are to be evaluated by HS1 squadron personnel.

As more modules of Procedure Training Aids are developed, it will be necessary to determine the proper mix of training aids and hands-on practice with actual equipment or training devices. Serious consideration must be given to the number of modules that may be completed before the student is given the opportunity for practice. Although the ideal situation may be to give the student an opportunity for hands-on practice upon completion of each module, scheduling equipment and training devices may make this impractical.

In summary, this evaluation has demonstrated the effectiveness of the Procedure Training Aid format for learning a complex procedure. Ultimately, this study provides a validation of the format model for the Procedure Training Aid for use in the Naval Technical Information Presentation System (NTIPS). This system is being developed for the Chief of Naval Material by the David W. Taylor Naval Ship Research and Development Center. It will be a state-of-the-art publishing system for preparing the operator, maintenance, training, and logistic support documents for new equipment. Improved formats for procedure training materials are an important part of the NTIPS design.

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